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The Gaseous Environment of Seyfert Galaxies

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Abstract. The VLA has been used to image HI in a heterogeneous sample of nine Seyferts as part of a continuing investigation of the role of galactic host gas in the triggering and fuelling of nuclear activity. Where previous single-dish observations indicated complex, poorly understood kinematics, improved angular resolution and sensitivity reveal tidal tails and intragroup gas, distinguish dwarfs from main disks and resolve non-linear gas dynamical features such as shocks in bars. Seyferts may be abnormally gas-rich, but a larger, statistically significant comparison of HI properties of normal and active galaxies is now required.

1. Introduction

The triggering and continued fuelling of Active Galactic Nuclei (AGN) is a key issue in astrophysics, but models involving release of gravitational energy via accretion are incomplete in their description of the interaction between the AGN and its environment. While the most luminous AGN, quasars, seem to coincide with violent dynamics in the gas-rich universe at the epoch of galaxy formation (Haehnelt & Rees, 1993), nuclear activity in nearby galaxies is more problematic, with reactivation of ubiquitous central black holes likely to dominate. Indeed, the rate of accretion or black-hole formation and growth may be regulated by host galaxy properties, such as galactic disk instabilities at different epochs (e.g., Shlosman & Noguchi, 1993; Sellwood, 1999). The relative proximity of Seyfert galaxies makes them ideal for the detailed study of both the AGN and its relationship to the host galaxy environment.

2. HI Studies of Seyfert Hosts

Statistical studies of Seyfert hosts, conducted mainly at optical and IR wavelengths show no conclusive links between nuclear activity and host properties, such as bars or interactions - possible mechanisms for triggering and fuelling activity. HI may be a better probe on sub-pc to 100 kpc scales than the stellar component, often exhibiting dramatic tidal disruption (e.g., NGC 3227 - Mundell et al., 1995) and reacting non-linearly to even weak barred potentials (e.g. Mundell & Shone, 1999). Few detailed studies of HI in Seyferts have been performed (Brinks & Mundell, 1996), so we have embarked on a study to investigate gas content, transport, distribution and activity-inducing features such as

bars and interactions. Details of nine systems are summarised in Table 1, with optical, HI and radio continuum images shown in Figure 1.

Table 1. Summary of Seyfert host properties

Seyfert Galaxy (Type)	Host Type	Vsys km/s	Resolution arcsec (kpc)	M_{HI} (10^9 $M_\odot$)	Interacting? (Companion)
N3227 (1)	SAB(s) pec	1135	20×18 (1.5×1.3)	1.1 (total) 0.57 (disk) 0.21 (cloud)	Yes (NGC3226)
			61×58 (4.4×4.2)	0.13 (N tail) 0.18 (S tail)	
N3982 (2)	SAB(r)b	1109	18×17 (1.3×1.2)	1.34	Possibly (NGC3972)
N4051 (1)	SABbc	725	18×15 (0.9×0.7)	0.71	No
N4151 (1.5)	(R')SAB(rs)ab	998	6×5 (0.4×0.3)	3 (total) 0.58 (bar)	No
N4939 (2)	SA(s)bc	3111	24×20 (4.8×4.1)	25.1	No (probably)
N5033 (1)	Sbc(s)	875	20×17 (1.1×1.0)	7.0	No (Disk warp + 4 HI clouds)
N5506 (1.9)	Sa pec sp.	1815	22 × 20 (2.5 × 2.3)	0.67 (tidal?)	Yes (NGC5507)
			60 × 47 (7.1 × 5.6)	>2 (total)	
N7469 (1.2)	(R')SAB(rs)a	4920	20 × 18 (6.4 × 5.9)	>2.57 (N7469) 1.17 (IC5283)	Yes (IC5283)
N7674 (2)	SA(r)bc pec	8713	22 × 20 (12 × 11)	>27.2 (total) 1.5 (cloud)	Yes (UGC12608)

2.1. The Need for Statistical Surveys

Host-galaxy gas represents a reservoir of potential fuel for an AGN, and given the ubiquity of supermassive black holes (Richstone et al., 1998), the differences between normal and active galaxies must be more closely related to the nature of the feeding rather than the presence of a black hole. A key question, therefore, is whether the gaseous properties of normal galaxies differ from those with Seyfert nuclei. Early results suggest that Seyfert hosts may be abnormally gas-rich (Hunt et al., 1999) but a systematic, statistical comparison is now required, achievable with a deep HI imaging survey of a matched sample of Seyfert and normal galaxies. This will have wider application relevant to issues of galaxy formation and evolution, e.g., the study of intragroup clouds and the issue of these as tidal tails or relic material (e.g., see NGC 5506 in the Rogues Gallery this volume). This gas would then provide tests of hierarchical structure and galaxy formation, may explain Lyα clouds seen towards quasars (e.g., Blitz et al., 1999) and possibly provide a new AGN fuelling mechanism.

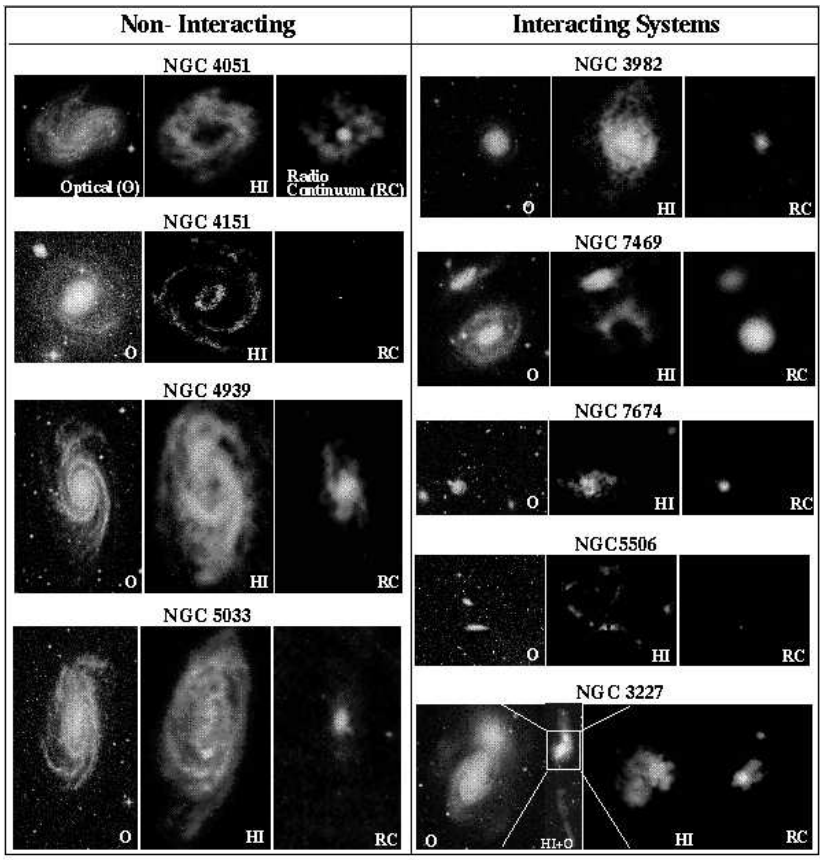

Figure 1. Optical (DSS2), HI and radio continuum images

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